VTOOLS Minus DAvid  
Project Proposal

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# Overview

## Problem Statement

To model a simple rat ecosystem in which the agents—rats—attempt to maximize their reproduction constrained by the food and water available in their environment. The rats will attempt to acquire the food they need in order to mature and mate (local decisions). The environment itself will only provide enough food to sustain a certain rat population. The rat population as a whole will be affected by the carrying capacity of this ecosystem, leading to global coherence.

## Agent Design

There will be two distinct types of rats: male rats and female rats. Both types of rats have the same objective as described in the problem statement: to maximize their reproduction.

Rats will be born with the following properties (note that at the beginning of the game, an input number of rats will be spawned to commence the simulation):

* Age y where y is the time the rat has been alive measured in t, rat time units.
* Time since Last Meal m where m is the time since the rat has eaten in t, rat time units.
* Hunger Factor µ = m/1000
* Sexual Desire Factor s where s is a piecewise function. When 0 <= y <= 25000, s = 0. When y >= 25000,   
  s = 0.5 + 0.00004y
* Aggressiveness Factor α = (µ + β)/2 where β is an aggressiveness constant based on the aggressiveness of the parent rats (or initiated in the initial population around a normal distribution of 0.5) as 0 <= β <= 1 where male rats are inherently more aggressive than female rats.
* Physicality p = (y/50000 + µ)/2.

Based on these properties, we can see that the hunger factor is directly dependent on time since the last meal. The sexual desire factor is a function of age, assuming that, as rats approach their death, they become more desperate to mate. Aggressiveness is a function of hunger factor and a constant, assuming that hungry rats are more aggressive, and that aggressiveness is also affected by a constant determined at birth. Physicality is a function of age and hunger factor. Hungry rats are more aggressive, but are less physically fit. The physicality of rats is also directly impacted by their age, assuming that older rats have more mass and experience to use to their advantage.

Food resources will have the following properties:

* Food source capacity “c” where 0 < c < 5, manipulated by simulation input.
* Within the ecosystem, food resources will appear in specific areas that signify grates in the streets above the rats’ environment. The number of active grates multiplied by the number of food items available at each grate will never to exceed the inputted global max food available at any given time.
* Rats that die in a conflict will become a food source where “c” = 1.

Rat agents can take various actions:

* Exploratory mode—looking for food or mates (depending on sexual desire factor and hunger factor). If the sexual desire factor is greater than its hunger factor, the rat will explore for rats of the opposite sex who are also searching to mate. If the rat’s hunger factor is greater than its sexual desire factor, it will explore for food. Rats move one tile per 10 rat time units (see below for scenario details). At meeting an intersection of paths, rats will randomly select to go straight, right, or left with equal weight.
* Eating mode—attaching to and depleting food resource. If a rat exploring for food (see explanation above under “exploratory mode”) finds food, it will enter eating mode. It takes rats t = 100 rat time units to consume their meal, at which point m (Time since Last Meal) will be reset to 0.
* Mating mode—a male rat attaches to a female rat for t = 100 rat time units. If a rat exploring for a mate (see explanation above under “exploratory mode”) finds a mate, it will enter mating mode. Mating mode will result in 8-12 baby rats (randomized: reflects actual rat birthing).
* Fighting mode—two rats fight when conflicting over a food resource or mate. Willingness to fight is determined by the aggressiveness factor as compared to a threshold which can be manipulated as input. The probability of a rat winning the fight is the ratio of its physicality to the total physicality of the two rats involved in the conflict.

Scenario details:

* The layout of the sewer will be tile based. It will follow a common “city-block” layout with 6 intersections.
* The layout will wrap. A rat leaving the environment will reenter the scenario from the south sewer path. Hence the scenario is a contained environment.
* Rats and food resources or other rats occupying the same tile will be aware of each other and decide on the appropriate action to take.
* Rats will move at a consistent speed and turn randomly upon reaching one of the six intersections.

Death conditions:

* If Time since Last Meal m >= 1000, the rat will die.
* When two rats enter fighting mode, one will die (see “Fighting Mode” above)
* Rats are assumed to die at y = 50000 of old age.

## Desired Emergent Behavior

We expect that rats will mate in the specific areas mentioned above where food resources appear. We suspect that, based on the fact that a rat’s purpose to explore in the exploratory phase is either to acquire food or to mate, that the majority of rat matings will occur near food sources. Rats will meet their need for food at these food sources, resetting their hunger factor to 0, and causing the sexual desire factor to be much higher, and the purpose of their exploring to be to find a mate. Secondarily, other rats of the opposite gender will likely have convened at the food source (depending on the food source capacity), and when they have also met their need for food, mating is likely to occur.

## Hypotheses

Hypothesis 1: Decreasing the aggressiveness threshold will increase the number of inter-rat conflicts, the number of rats in fighting mode, and the number of rats serving as food sources.

Hypothesis 2: Over time, the aggressiveness of the rats will converge to a constant.

Hypothesis 3: Aggressiveness and life expectancy of rats are inversely correlated.

Hypothesis 4: More aggressive rats are less likely to win fights based on the effects of the time since the rat has eaten on physicality and aggressiveness.

Hypothesis 5: As the food source capacity is lowered, the proposed emerging behavior will minimize as it will be less likely that a rat of the other gender will be present at the food source if the capacity is low.

Hypothesis 6: Aggressive rats will fare better when the global food source availability is low as compared to when the global food source capacity is high.

Hypothesis 7: Rats will kill proportionally more rats of the same sex than of the opposite sex, with the disparity enlarging as food source capacity and global availability are increased, causing the killings to be motivated primarily by competition over mates.

## Experiments

We will vary the following parameters in our experiments by the associated range of values. Each experiment will be run 30 times (= 600 total tests)

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| Parameter | Range of Values |
| I: Aggressiveness Threshold | 0.25, 0.5, 0.75 |
| II: Food Source Capacity | 1,2,3,4,5 |
| III: Global Food Source Availability | 0,1,5,10 |
| IV: Initial Rat Population Size | To be determined\*\* |
| V: Initial Rat Population Aggressiveness Constant | Normal Distribution around 0.5 |

The parameters varied include the aggressiveness threshold (at what threshold rats’ aggressiveness must overcome for them to enter fighting mode over food or mates), the food source capacity (the amount of food available at each food grate), the global food source availability (the total amount of food available at any one time at all of the food sources combined), initial rat population size, and initial rat population aggressiveness constant (how relatively aggressive the rats are apart from the effect of the hunger factor on the aggressiveness). While scenario analysis is being run on any one of the five above parameters, the remaining four will be fixed at the mean value of the ranges described above. Hypotheses 1-3 are based on the effects of varied aggressiveness of rats, and will be tested by variation of the aggressiveness threshold: parameters 1. Hypothesis 5 is based on the impact of lower food source capacity will be tested by parameter 2, the food source capacity. Hypothesis 6 is based on the impact of global food source availability, and will be tested using parameter III.

\*\*We will find an initial population size such that the birth rate is greater than the death rate at the beginning of the simulation, and then fix the initial rat population size at that quantity for the duration of the experiments.